A Report to

Kansas Department of Health and Environment
Bureau of Water, Watershed Management Section

Kansas Grazing Land Water Quality Education Program
Final Comprehensive Report

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Partial financial assistance for this project has been provided through
EPA -Section 319 Non -point Source Pollution Control Grant C9007405-00,
through a grant agreement with the Kansas Department of Health and Environment.

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I. OBJECTIVE AND HISTORY

A. Objective

The objective of this project was to develop an educational program to promote improved water quality from Kansas grazing lands while maintaining profitability.

B. History

In 1995 an educational publication for grazing land managers was produced entitled: *Managing Kansas Grazinglands for Water Quality* (Ohlenbusch et al., 1995). It presents an overview of water quality associated with Kansas grazing lands and describes how grazing management principles and practices can be applied to benefit water quality. This publication was a multi-agency effort led primarily by Kansas State University Research and Extension and Kansas Department of Health and Environment (KDHE). Beginning in 1997, funds were provided to the Kansas Grazing Land Water Quality Program (KGLWQP) to document water quality problems associated with grazing land and develop educational material to support producer development of economical improvement strategies in a study area near the KSU campus. The State Water Plan funded the first year of the project and subsequent years were funded primarily through four consecutive annual EPA Section 319 grants. Additional sources were KSU Extension Agronomy operating funds which contributed an unknown amount for copying and printing, and the Renewable Resource Extension Act of 1978 which contributed $55,865 to wages and salaries and $9,700 for new equipment. Additional funding from miscellaneous KSU sources included $1,987 in salaries and wages and other expenses and $6,912 in equipment. The Water Quality Financial Analysis and Resource Evaluation (WQFARE) process and support material are the culmination of this effort (included in Attachment 1).

The process of developing WQFARE, communication with cooperators and natural resource professionals, and the review of available literature brought to light the opportunity and need to expand the audience of this producer educational program. Key persons involved with KGLWQP within the study area and elsewhere indicated that a state-wide educational program would be most beneficial. Rather than developing a short-term educational program to address just current water quality needs in the project study area, a more useful strategy was development of materials for delivery via on-going Extension programming. The resource inventory and evaluation process was tested outside the initial study area and determined to be suitable for state-wide use. This extrapolation is possible because WQFARE is based on common grazing management, hydrology and economic principles.

A mid-project shift toward developing a state-wide process suitable for statewide deployment, plus recognition of the unconsolidated state of grazing land water quality publications, created the need for increased project exposure among the general public and also among professional audiences. Development of the project Web site was the first step taken to address this need. The site includes the project description, literature database and newsletters. Presenting project methods and findings to economic, water and range resource professionals for feedback was also considered essential. Professional meetings, publications and personal communications all provided valuable professional feedback.

Over the six years the program was in existence, the review of relevant literature, field inventories, and communication with cooperators and professionals, revealed that returning to fundamental ecological, economic, and management concepts was the best approach to understanding and conveying the relationship between grazing land runoff and water quality.

The dynamics of the grazing land system can be divided into eight concepts: a) runoff dynamics, b) nutrient and water cycling, c) bacteria, d) pesticides, e) livestock behavior, f) climate, g) economic environment, h) managerial ability and style, and I) water quality indicators. These concepts were further summarized for a brochure produced called *Understanding Grazing Land and Water Quality* (Attachment 2) which introduces the self-help WQFARE planning guide.

II. MANAGING GRAZING LAND WATER QUALITY

A. Literature Review

Literature reviewed by project personnel suggests grazing land water quality is most significantly impacted by vegetative cover and animal concentration. Insights from the literature review suggest that sediment, nutrients, and bacteria are the major potential pollutants associated with grazing lands. Delivery of theses pollutants to surface waters is highly dependent upon weather events, and the proximity of vegetative cover and animal concentration areas to watercourses. However, it is also important to note that any terrestrial ecosystem will yield some ‘background’ level of these (and other) constituents. Additional contamination associated with livestock grazing can be minimized by practicing sound grazing management which occasionally requires system-specific investments in capital improvements.

B. Understanding the Issues

Climate

Extremes in temperature, rainfall and snowfall in Kansas result from its central position within the continent. A 30 inch range in annual precipitation from the semi-arid west to the sub-humid east is influenced primarily by the Rocky Mountain “rainshadow” and moisture from the Gulf of Mexico. This precipitation regime not only contributes to hydrologic variability across the state, it also contributes to diversity in vegetation and productivity.

Regardless of annual precipitation averages, intense events can result in significant runoff resulting in sediment and other compounds being transported to water resources. Extreme precipitation events may induce and/or exacerbate erosion. Well managed grazing land, should allow such disturbed systems to return to a stable state with little or no human intervention in a relatively short period of time. Management to minimize erosion might include ensuring adequate vegetative cover (Figure 1) is present throughout a pasture, restricting/prohibiting access to eroded areas, terracing, and/or the addition of plants, rocks, tree branches, etc. to help the erosion ‘heal.’

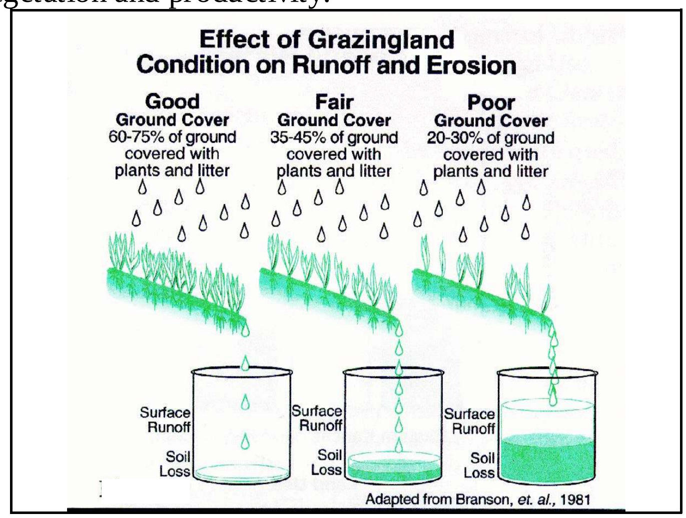

Figure 1 The nature of vegetative cover and runoff. (After Branson, et. al, 1981)

From a management perspective, climatic influence on production may be a significant factor when considering alternative management strategies such as the establishment of cool season forage to reduce dormant season feeding requirements. Extended periods of below average precipitation is a natural occurrence in Kansas. Management of grazing resources should take this possibility into account in long-term planning. For example, failure to reduce stocking rates following drought conditions may result in poor vegetative cover and declining range condition.

Runoff Dynamics

The concept that runoff occurs when precipitation rate exceeds the ability of the soil surface to absorb the water (infiltration) is well known. Three critical factors affect this relationship. First, the infiltration rate of a soil surface is a function of gravity, surface cover (standing and mulch) and (macro and micro) pore space. Second, the physical characteristics of soil profiles present affects runoff due to their differential ability to transmit or hold water under varying soil moisture conditions. Finally, topography (slope, aspect, and terrain) can further affect infiltration.

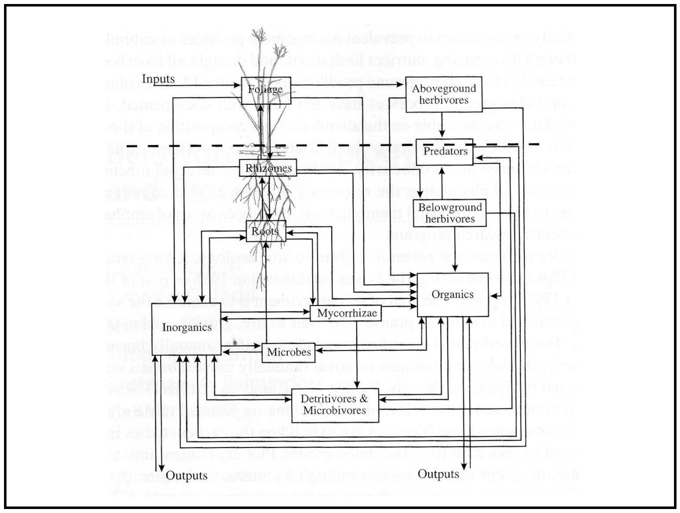

Figure 2. The carbon cycle after Rice, et. al., 1998.

Nutrient and Water Cycling

Nutrients are needed for plant growth and are primarily supplied either through natural processes in the soil or from the air. Soil sources for nutrients include soil particles, organic matter, and inorganic fertilizer. The importance of the carbon, nitrogen, phosphorus, and water cycles to plant production and water quality is described below:

Carbon, while not considered a contaminant, is an important part of the plant-soil-water system. It is the building block of plant and animal tissues (Figure 2). The major source of carbon is CO_2 in the atmosphere. When combined with water and nutrients in the plant leaf, plant tissues are produced through photosynthesis. Carbon is sequestered in the soil via root storage and microbial biomass. Organic matter (plant and animal material on or near the surface) breaks down releasing carbon. Organisms that consume plant material also release carbon through respiration usually in the form of CO_2.

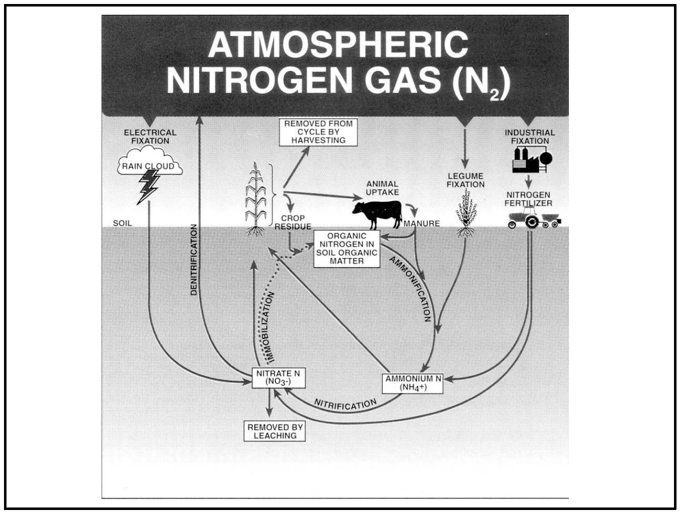

Figure 3. Nitrogen cycle after Devlin, et al., 1996.

___Nitrogen is a primary plant nutrient. It is also designated as a potential contaminant. Nitrogen occurs in the environment in several forms (Figure 3). It occurs in the air (about 78% of the atmosphere is made up of nitrogen gases),

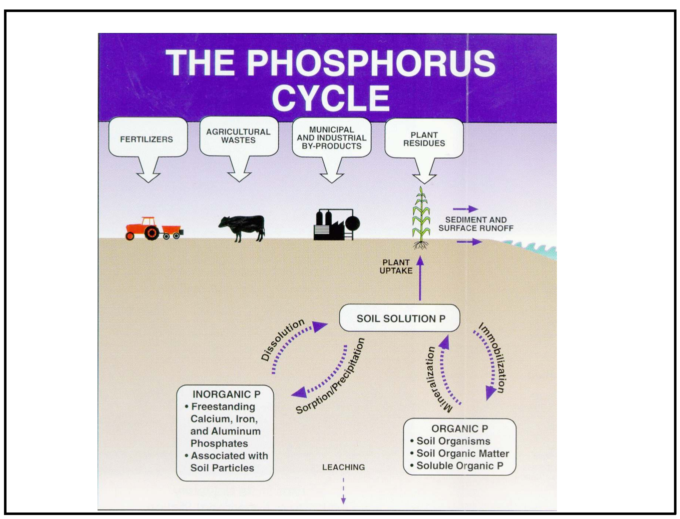

Figure 4. The nitrogen cycle after Devlin, et al., 1998.

attached to soil particles, in plant and animal tissues, and in soil water. Nitrogen is also released through mineralization of soil material. Grazing animals excrete it in urine and manure which enters the nitrogen cycle through decomposition. Nitrogen can enter streams attached to suspended solids or dissolved in water.

Phosphorus is a primary plant nutrient important in root development and plant growth as well as in the assimilation of other nutrients. Phosphorus is relatively insoluble and does not move readily in the soil. It is also designated as a potential contaminant. Phosphorus occurs in organic and inorganic forms (Figure 4). Organic forms are derived from the breakdown (decomposition) of organic matter through microbial activity. Inorganic phosphorus comes from soil mineralization of parent material and soil particles and from fertilizers. Both forms can be immobilized or adsorbed onto soil particles making them unavailable to plants and restricting movement in the soil. Grazing animals excrete phosphorus in manure which enters the cycle through decomposition. Phosphorus can enter streams attached to suspended solids and dissolved in water.

Suspended solids are also one of the major contaminants found in Kansas waters. Change in the flow dynamics of runoff will change stream sediment load and associated dissolved contaminants. Stream flow volume and velocity influence potential suspended solid load. Stream bank and/or bed erosion can contribute suspended solids in addition to the contribution from overland flow.

As flow dynamics increase, changes in stream channels occur. Changes can occur as a deepening and/or widening of the channel, over-topping of banks resulting in sediment deposition, or both. If restrictions to flow occur, changes in the channel or flood plain can result. Any of these actions can add to contaminants leaving the land and moving into the flow.

Bacteria

Waterborne illness and disease, which can be caused by a variety of microorganisms, is often attributed to the contamination of water resources with fecal matter. Fecal coliform (FC) bacteria presence in water has been determined to be the preferred indicator of risk associated with fecal contamination however, the pathogens FC serve as indicator for may not have the same persistence characteristics. However, recent research (Kistemann et al. May 2002) concludes: "...reliance on the coliform group creates serious problems in measuring environmental quality and in assessing risks for public health" (2002, 2195-96).

Similar to other forms of non-point source pollution, increased FC levels may be measured during high flow conditions. Higher FC levels are also consistently found during the warmer months of the year. Further research is needed to fully understand and explain FC growth/survival in manure and soil, and subsequent transport to streams. Likewise, the persistence, flushing and re-suspension of fecal coliform bacteria already living in the aquatic environment is poorly understood.. But Kistemann et al. (May 2002) suggest substantial shares of total microbial loads in watercourses result from rainfall and extreme runoff events.

An unpublished review of 78 studies of fecal coliform bacteria (FCB) sources by (Snethen 2001) indicates concentrations of FCB vary greatly. FCB colony counts measured in these 78 studies varied between 4 (Coltharp) coliform units (ungrazed rangeland) and to 6,300,000 (Olivieri) coliform units (raw sewage) per 100 ml of water. There were 14 studies that referenced FCB counts in association with grazing activity on the land where runoff was measured. Counts for these studies ranged between 4 (Coltharp) coliform units (ungrazed rangeland) to 110,000 (Doran and Linn) coliform units (grazed pasture) per 100 ml of water. It should be noted none of the studies reporting grazing activity were conducted in Kansas.

Table 1 shows FCB counts (per 100 ml) by study that reported grazing activity. Nine of the 14 (64%) studies referenced had FCB counts between 100 and 10,000 per ml, with 2 below and three above this range. Eight of the 14 studies (57%) experienced FCB counts below the 2,000 per 100ml recreational water quality standard in Kansas.

It is interesting to note that in all cases where FCB count was above the 2,000 count/100ml Kansas standard (except the study with the largest FCB count) the grazed area was receiving fertilizer amendments in the form of poultry manure/litter or inorganic fertilizer. Snethen believes the studies with <= 2,000/100ml FCB counts probably represent more typical grazing conditions in Kansas.

Table 1. Fecal Coliform Bacteria Grazing Activity Reported. (Snethen, 2001)

StudyID	4	5	7	12	6	17	13
Count	38	88	130	260	800	1,000	1,500
StudyID	16	27	9	30	29	2	10
Count	2,000	3,700	4,200	8,700	27,000	55,000	110,000

In 8 studies (from the review above) sampling FCB in pastures under natural conditions (i.e. undisturbed, no -grazing) FCB counts ranged from 4-13,000 per/100ml (Table 2). However, 7 of these 8 (88%) studies experienced FCB counts between only 4 and 470/100ml. One of these studies(indicated by * in table) was conducted in Kansas.

Table 2. Fecal Coliform Bacteria Natural (undisturbed) Conditions

StudyID	3	14	18	78	36*	19	15	11
Count	4	4	60	100	100	180	470	13k

Pesticides

Pesticides are used for brush and weed control on grazing lands. Some are used on a voluntary basis while many are used to meet the legal requirements of the Kansas Noxious Weed Law. As a general rule, using a herbicide according to label instructions and observing all cautions will rarely result in herbicides entering runoff. Examples of exceptions to this generality include: heavy rainfall immediately after application or direct application to streams. Figures 5-7 illustrate the relative use of pesticides (percent of acres treated, acres treated, and application rate) on graze land in Kansas compared to that on other agricultural lands (Cress, 1994).

Livestock Behavior

Watering locations preferred by livestock commonly have the greatest influence on animal activity in a pasture because thirst is their primary physiological demand. Loafing and social interactions tend to prolong concentration around watering points. Loafing may be prompted by the need to rest, ruminate and/or take advantage of evaporative cooling. Social interactions include pecking order establishment, suckling and breeding.

Livestock preference between similar watering facilities in the same pasture is

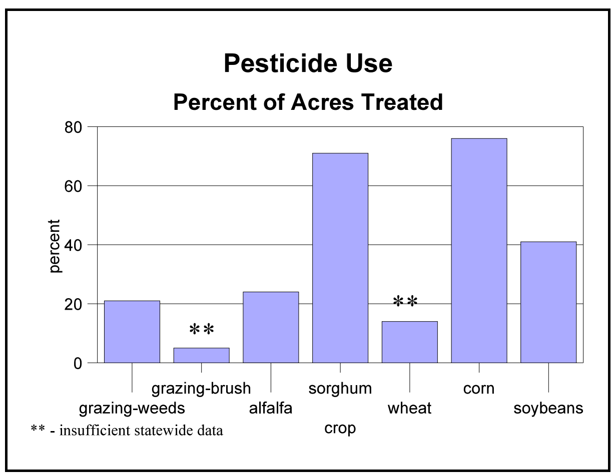

Figure 5. The percent of acres of graze land treated with pesticides during 1993. (Cress, 1994)

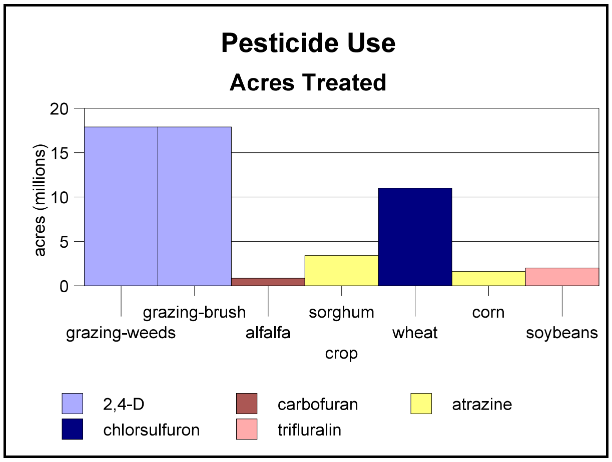

Figure 6. The acres of graze land treated with pesticides during 1993. (Cress, 1994)

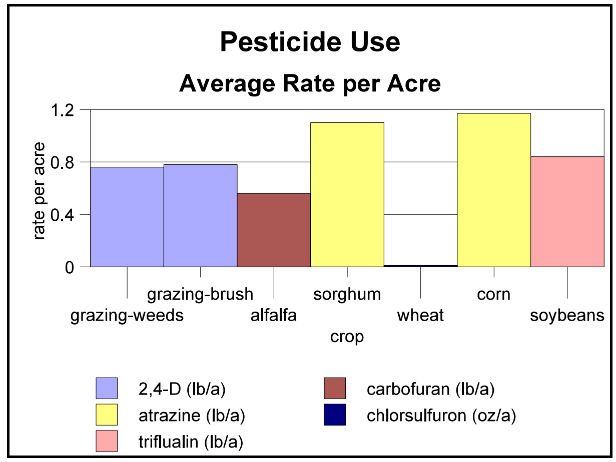

Figure 7. The average rate of various pesticides applied to graze land in 1993. (Cress, 1994)

usually influenced by proximity to shade, feed and other factors that satisfy other physiological needs. Observations suggest that, all other factors being equal, livestock prefer water facilities in the following order:

1. trough
2. pond
3. pool in stream, and
4. flowing point on stream

It is not known why livestock prefer watering from a trough and generally avoid watering from flowing points on streams. Temperature, taste and fear may contribute to these preferences. Palatability and water temperature have been shown to significantly influence water consumption. A variety of safety concerns may also be associated with watering facilities. Ice, mud or collapsing stream banks may cause injury or even death. It is also reasonable to assume that livestock may instinctively prefer watering at locations having good visibility to avoid predation.

The numerous factors mentioned here simultaneously influence pasture use by livestock. This helps demonstrate the complexity of grassland systems and the challenge of using generic grazing management recommendations to address water quality issues.

Water Quality Indicators

Physical relationships between water resources, vegetative cover and livestock concentration areas can indicate pollution potential. The density and area of vegetative cover separating areas of livestock concentration from water resources are critical indicators. The cover density and amount of separation needed to hold pollutant loading (over time) to natural levels is dependant upon the third indicator, the intensity of concentrated use.

Characteristics of adequate cover will vary across the different regions of the state due to differences in climate, soils and stocking rates. For example, 4-6 inches of standing cover consisting of dense tall-grass species may be adequate on a lowland range site in eastern Kansas while only 2-3 inches might be adequate for a similar range site in western Kansas.

Areas of inadequate vegetative cover and concentrated livestock waste are, to an extent, predictable based on livestock behavioral response to management features and pasture physiography. Livestock behavior can be used as a tool to improve cover conditions and/or relocated concentration areas by adjusting where, what, and when management decisions are implemented. The location of management features such as ponds and feeding areas, stocking density, stocking rate, and season of pasture use all potentially influence water quality. Timing of practice implementation compared to weather events can also determine if management decisions contribute to pollutant loading. Potential concerns and pollutants that may result are listed in Table 3.

Table 3. Grazing Land Water Quality Concerns and Associated Pollutants.

Potential Concern	Potential Pollutant			
	Phosphorus Compounds	Nitrogen Compounds	Sediment	Fecal Coliform
Poor Grazing Distribution	**		**	
Overgrazing	**	**	**	**
Access Roads			**	
Animal Trails and Walkways	**		**	**
Invasive Woody Species			**	
Stream Channelization	**	**	**	
Poorly located and abandoned fences	**	**	**	
Concentration Areas	**	**	**	**
Watering Point Location	**	**	**	**

C. Developing the Database

The initial literature search revealed a comprehensive, readily available database of literature relevant to water quality associated with grazing lands did not exist. The single database available was a database entitled *Livestock Influences on Riparian Zones and Fish Habitat* developed by Oregon State University Extension Service. It consisted of 1,350 citation published prior to 1995. This resource was primarily developed for grazing influences on fisheries in the mountain West. Later, a similar database at the University of California-Davis Extension was also considered. Both efforts were discontinued due to copyright issues. Ironically, the important individual documents from those databases were added to the project database through the normal literature review (Table 4). More recent compilations of applicable literature include EPA's *Draft National Management Measures to Control Nonpoint Source Pollution from Agriculture*, an extensive literature review published by the U.S. Forest Service entitled *Drinking Water from Forests and Grasslands*, and a separate USDA literature compilation entitled *Managing for Enhancement of Ripairan and Wetland Areas of Western the United States: An Annotated Bibliography*

Table 4. Growth of citations during the project.

1998	350
1999	1,072
2000	2,100
2001	2,400
2002	2,511

Throughout the project, expanded literature search methods, including utilization of internet and automated library search tools, were identified that helped to efficiently locate the most applicable water quality and grazing management research and educational material. Through theses efforts, some of the most current and useful information relevant to grazing land water quality issues were obtained, some while still in press.

Over time it became apparent that less emphasis should be placed on reviewing literature and more emphasis placed on its organization and accessibility. Source variability and detail of the published information challenged the time and resources available to not only review the documents, but to locate material later.

For example, information applicable to Kansas grazing land water quality issues can be found in published material specific to Western rangelands, Eastern pastureland, and grazing lands in other countries. This material is written by people with backgrounds in engineering, animal science, agronomy and ecology and published in scientific, educational, or popular formats. The more practical approach to utilizing the best available information was to catalog the citations, keywords and comments in a searchable format that could be used by the project staff and to anyone researching grazing management and water quality issues.

Information Support Services for Agriculture (ISSA) in Hale Library learned of our developing database in 2000 and expressed interest in helping extend its utility. An evaluation of the potential to integrate the citation database into the KSU Digital Libraries system was then initiated. Using the state-of-the-art ENCompass search engine and information architecture by Endeavor (http://www.endinfosys.com/) will offer a means of accessing the citations, their full-text counterparts, and other digital resources related to grazing lands water quality. Implementation will begin with export of the Microsoft Access database table to records using Dublin Core (DC) metadata to classify the documents. DC is a widely recognized international standard for describing digital information resources, and can be combined with metadata such as Content Standard for Digital Geospatial Metadata (CSDGM) should we add resources in those formats later on.

The Literature Database developed by project staff currently contains over 2,500 citations. The database covers material relevant to grazing lands and water quality from 1927 to the present. Most citations are from U.S. sources, however the material in the database has been gleaned from sources in over 30 countries. Full text paper copies are available and contained in 32- 3" D-ring notebooks plus books, reports, and proceedings. Citations are available through the literature database web site at http://www.oznet.ksu.edu/glwqld/. Approximately 350 additional citations await location, classification, and entry into the database.

Through support from the Information and Education Technologies office of Kansas State Research and Extension, *Webtrends*, a process that monitors who, when, and how individuals access a web site, was added to the database site. In the third quarter, 2001, and the first quarter, 2002, there were 1,611 visits to the project website from over 20 countries. The top 5 countries were U.S., Canada, Japan, Germany, and Australia.

D. Moving Away From Best Management Practices (BMPs)

Traditionally, conservation agencies have encouraged water quality improvement by promoting certain managerial and capital improvements referred to as Best Management Practices. This terminology has led to a perception that practices identified as BMPs can consistently resolve water quality concerns.

EPA's recently released *Draft National Management Measures to Control Nonpoint Source Pollution from Agriculture* includes a brief but useful review of the term (EPA 2000). It is helping shift federal guidance targeting the management of private agricultural resources toward a systems approach. Rather than BMP's, the EPA is beginning to promote use of the term "management measure." A management measure is defined as "a group of affordable management practices that are used together in a system to achieve more comprehensive goals – such as sustainable water quality improvement."

According to the EPA draft document: "...the term management practice is used in lieu of BMPs since 'best' can be a highly subjective and site-specific label." Referring to the BMP use in the United States, this document adds: "...a practice may be considered best in one area (e.g. coastal plain) but inappropriate in another area (e.g., mountains)." Further, this document points out the underlying reason why usage of the term BMP is problematic: Criteria for determining what is best may include determining the extent of pollution prevention or pollutant removal, ease of implementation, ease of maintenance and operation, durability, attractiveness to landowner (e.g., how willing will farmers be to implement the practice in a voluntary program?), cost, and cost-effectiveness. (Chapter 2, p. 2-25)

E. Field Inventories

Study Area

The initial study area focused on cooperator land in portions of the Black Vermillion River, the Big Blue River both (HUC-8 designation 10270205), the Little Blue River (10270207), Vermillion Creek (10270102), and the Nemaha River (10240007) watersheds. All these watersheds are located in Marshall, Nemaha, and Pottawatomie Counties in Northeast Kansas.

The study area expanded with the addition of cooperator land in portions of the Chikaskia River (11060005), Beaver and Deer creeks (10260012), Buckner Creek (11030006), Mulberry Creek (10270207), and the Smoky Hill River (10260006) watersheds. These watersheds are located in Kingman, Phillips, Hodgeman, Washington, and Russell counties, respectively.

Expansion of the study area (Figure 8, Table 5) facilitated development of educational materials suitable for state-wide application and testing of materials for any necessary refinements. All of the expanded study area watersheds are ranked as Category I (in need of restoration) and a top priority in the Kansas Unified Watershed Assessment (Figure 9).

Physical Inventory

___A physical inventory was developed for each producer-volunteered operation. This inventory consists of a confidential database that includes location and characteristics of soils, vegetation, areas of erosion and livestock concentration, current and abandoned management facilities, water resources -- including wells, ponds and streams -- and other physical factors that can be related to water quality. Technological tools, including geographic information system (GIS) software and a global positioning system (GPS) receiver linked to a pen-based field computer, were used to acquire and manipulate field-level information and ground-truth background digital aerial orthophotography.

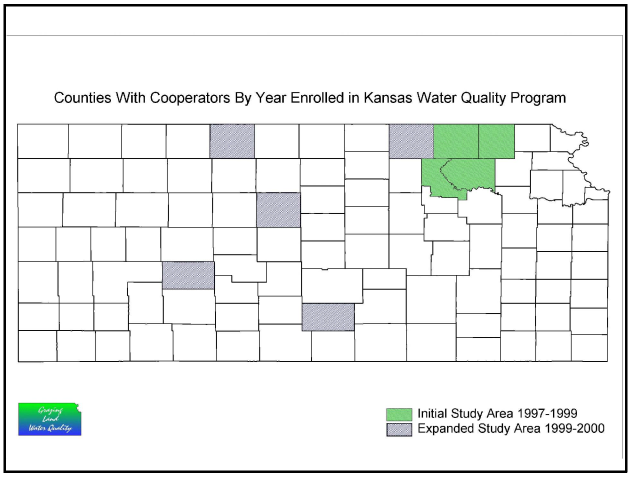

Figure 8. Graze land Water Quality Program study area

Field inventory process

Pastures were inventoried one at a time beginning in a counter clock-wise pattern around the perimeter. Traveling the perimeter

Table 5. Cooperator Grazing Acreage Statistics

Cooperator No.	No. of Parcels	County	Total Grazing Acres (Reported[1])	Individual Cooperator % of Total Grazing Acreage	Status[2]
1	2	Marshall	910	4.0%	A
2	4	Pottawatomie	1,960	8.6%	A
3	7	Marshall	2,750	12.0%	D[3]
4	8	Pottawatomie	1,546	6.8%	A
5	12	Pottawatomie	1,784	7.8%	A
6	2	Pottawatomie	830	3.6%	D[4]
7	1	Pottawatomie	1,570	6.9%	D[4]
8	1	Nemaha	417	1.8%	A
9	6	Pottawatomie	6,500	28.4%	A
10	1	Kingman	2,263	9.9%	A
11	1	Nemaha	160	0.7%	A
12	2	Phillips	338	1.5%	A
13	1	Hodgeman	1,500	6.6%	A
14	1	Washington	80	0.3%	A
15	3	Russell	289	1.3%	A
Totals	52		22,897	100.0%	

1 Acreages are generally cooperator reported figures, not actually measured via GIS.
2 At the project end, A = active, I = inactive, D = dropped out
3 No longer an active livestock producer.
4 Currently inactive, primarily because management data has not been supplied.

and reviewing the orthophotography helps to determine the extent to which the interior of the pasture must be traversed. This systematic process was helpful for collection and interpretation of data, but could not always be followed due to access or other limitations. A Fujitsu 1200 pen-based field pc using GeoLink software and a Trimble AG132 GPS mounted on a Polaris 400 all-terrain vehicle (ATV) were used to accurately locate physiographic and management features relevant to grazing management and water quality.

Additional field equipment and materials includes aerial digital orthophotography printed on paper (ortho fieldmap, see Attachment 10 for more information), a compass and a Kodak DC-120 digital camera. The location of photo-points were collected with the GPS so feature changes can be monitored over time using repeat photography. Pick-lists were developed in GeoLink to help automate feature attribute data entry into the field-pc. When features could not be accessed by the ATV, offset gps points or lines were taken or the data was recorded on the ortho fieldmap and/or on hand-drawn maps. The compass was used in these instances to record bearings from the gps location to the feature.

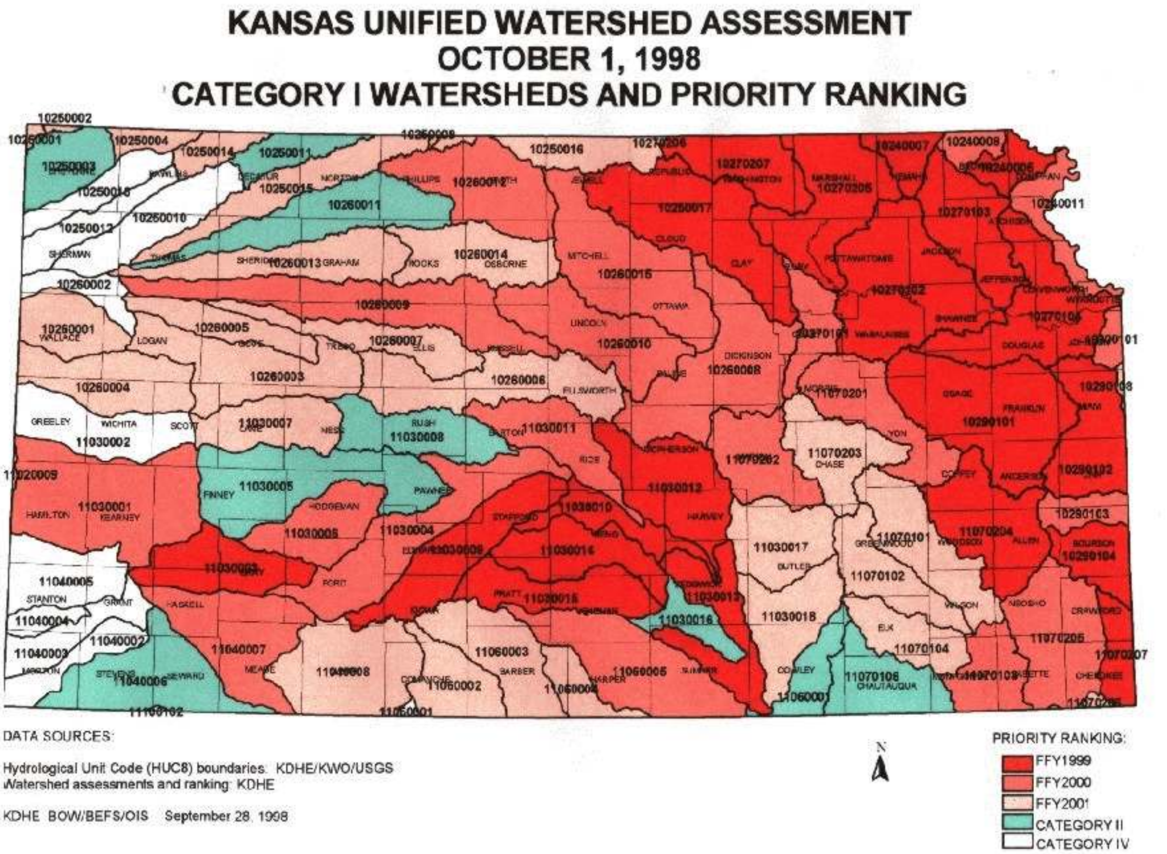

Figure 9. Kansas Unified Watershed Assessment (Category I watershed in shades of red)

GIS utilization

Entry of field data into the GIS (ArcView version 3.2) provides the ability to examine relationships in the data by being able to 'layer' data in unique combinations of information – customizable to a given situation. Examples of field data layers collected include: ponds, streams, springs, troughs, draws, fencelines, gates, and areas of erosion. These layers of information were typically displayed over a background aerial Digital Orthophotographic Quarter Quadrangle (DOQQ – also used to produce the ortho fieldmap) or a digitized USGS quadrangle called a Digital Raster Graphic (DRG). For example, field data was overlaid on a DRG's to determine realistic routing and lengths of a proposed water pipeline based on topographic contours. The project also used photographs to document pasture conditions. These are digitally linked to the photo location so that they can be displayed on the computer screen to enhance pasture analysis.

___On average, there are approximately 18 layers of data used for each parcel of a given cooperator. About 80% of these layers represent field-collected data. The remaining are imported from existing databases – such as the Public Land Survey System (PLSS) or project made – such as parcel boundaries, or derived data – such as rangesite polygons developed from the NRCS SSURGO database. Rangesite information is very important to determine appropriate pasture stocking rates and to examining livestock distribution improvement options because implicit in this information is the use made of available forage by livestock.

F. Management Profile and Economic Evaluation

___In order to develop and evaluate potential strategies for graze land water quality improvements, it is essential to establish a baseline, or beginning benchmark for the individual grazing operation. This benchmark is also valuable for evaluating the implementation and results of management changes made as a result of the WQFARE Process. This is accomplished by compiling detailed current management profiles, and collecting baseline economic data to evaluate the current management system and assess the economic efficiency of the enterprise as it is currently managed. The results of this evaluation may limit the management alternatives that are feasible for a given situation.

It is essential, for example, that proposed management changes fit into the overall farming and ranching operation from a management perspective. Changes must also be economically feasible in that they can be implemented with little or no cost or can be paid for through productivity enhancements or cost share programs.

Initial profiles (both management and economic) provide a baseline to document progress toward goals over time. This is consistent with traditional business planning and evaluation processes, in that monitoring of progress over time is essential. Within this framework, water quality goals, as well as the financial and other goals of the grazing enterprise can be achieved simultaneously.

Management Profiles

Management profiles were completed for all 12 active cooperators and economic profiles are complete for 6. Four cooperators did not have adequate records to complete an economic profile of their operation. After becoming involved in this program, all of these cooperators said they would begin keeping records. Adequate information, however, was not available before project termination to perform an adequate economic analysis. Economic analysis of improvements recommended for such cooperators need to be based on production and financial information observed in similar situations. The two remaining cooperators failed to return any economic information.

Economic Data

Challenges on the part of the cooperators to provide adequate economic information include insufficient record keeping and the time required to transform information suitable for income tax preparation into a format suitable for management and planning purposes One-on-one assistance from the Extension Assistant Agricultural Economics was time consuming, but vital to obtaining most of the baseline economic information obtained from cooperators. Unfortunately, the person in that position left the project early. Due to a combination of insufficient cooperator economic data and alternatives still being developed at that time, he was able to complete a comprehensive set of economic evaluations on proposed alternatives for only one cooperator. Development of decision support tools that either producers, Agronomy staff, or others involved in the process can use to complete such evaluations is underway. Budget limitations and uncertainty of future WQFARE delivery method(s) have precluded the completion of decision tools specifically for WQFARE. However, tools and business planning templates continue to be developed by agricultural economics staff that can easily be incorporated into the WQFARE evaluation and planning process.

G. Economic Implications of Decisions

Management is all about making decisions. In the context of managing grazing land for water quality, these decisions involve stocking rate, kind and class of animals, time of year the resource is used, strategies that may alter animal behavior, and perhaps investment in capital improvements. Individual managers may add additional decision considerations to this list.

Alternative management strategies or facility developments that can potentially impact water quality will likely have impacts on production performance, costs, or marketing options. Therefore, decisions regarding the choice and implementation of alternatives will have economic implications. It is important to consider not only the magnitude of the eventual production performance change that is anticipated, but whether the full change will manifest itself immediately, or over a period of years. Similarly, will cost changes be reflected in a one time event, or will the costs be spread out over a period of years? The economic implications of management changes and capital improvements depend on accurate answers to these, and other questions.

On the marketing side, since livestock is the primary commodity being produced on Kansas grazing lands, changes in the management system may yield changes in the timing of marketing, or in the kind and class of livestock being produced. Cooperators need to be aware of the long term nature of decisions to alter grazing management systems. Long term average price levels for the products being produced or proposed should be used for economic evaluation. In addition, seasonal price patterns exist for most livestock commodities, and should be considered when evaluating alternatives to the current system. Finally, cooperators need to be aware of the "price slide" reality present in most livestock marketing systems. Heavier calves, for example, are typically discounted relative to lighter calves. The important implication is that improvements or alternatives that are targeted specifically toward increasing individual animal performance need to consider the expected lower "per-pound" value of the heavier animals produced.

Proposed alternatives can involve relatively minor changes, or may represent fairly significant (major) changes in the way the grazing resource is operated or managed. Minor adjustments to the current management system will typically involve the same basic enterprise (kind and class of livestock), and will generally involve little or no long term capital investments. Major adjustments could involve a change in the basic enterprise mix, and may also involve significant levels of capital improvement expenditures. What is important is to compare true scale independent economic profitability across alternatives (including the base case) by computing measures such as economic return on investment or economic return on equity. In addition, cooperators are interested in comparisons of the absolute level of economic returns expected from each alternative.

With this in mind, so called "minor" adjustments in response to water quality concerns will typically have only minor economic implications. Current (base case) economic budget projections can be re-estimated incorporating assumed changed in productivity and operating costs. Projected return on investment, and the scope of absolute economic returns can be compared across alternatives using conventional budget projection templates developed for common spreadsheet software. Results should also be evaluated to determine the sensitivity to key assumptions so that risk management strategies can be developed and incorporated into the management plan. This can be easily accomplished withing the spreadsheet templates.

Even relatively major changes can be evaluated using relatively simple budget projection tools if the productivity changes that are expected to result from the management system changes occur fairly quickly, and/or if any net capital investments required are made at one point in time. When considering these types of alternatives, productivity and operating cost changes are incorporated into the budget projection framework. Net capital improvement costs are annualized using standard capital budgeting procedures, and the annualized costs are included in the budget projections. Return on investment, and the overall scope of the expected economic returns can be computed and compared to the base case, or to other alternatives. Again, the results need to be evaluated for sensitivity to key underlying assumptions.

In the most complex situations major changes can involve multi-period investments, or productivity changes may evolve over time as a result of a management change or capital improvement. Even then, the economic implications can be evaluated using time tested straight forward capital budgeting techniques. Unlike in the simpler situations, static budget projection tools are not adequate. However, a multi-period full cost budget can be set up using templates developed for readily available spreadsheet tools to compare the net present value of a proposed net income stream to that of the base case, or other alternatives.

III. EDUCATION NEEDS

A. Philosophy

The project developed educational materials are designed to help landowners and/or livestock operators assess and address potential water quality concerns on their land. Long term delivery of the water quality education program developed by KGLWQP will be via the ongoing Grazing Land Management Education Program. Delivery and review of the current materials will be most effective on an individual cooperator basis and as part of scheduled meetings.

B. Methods

WQFARE delivery without outside funding, will include a self-help guide and incorporation into future Grazing Management Workshops, a major part of the Kansas Graze land Management Program. With adequate funding two methods would be employed to accelerate WQFARE implementation statewide. Agricultural support professional training sessions would be used to instruct agency and organization personnel in delivery of WQFARE planning support. WQFARE Stewardship workshops targeted at producers in priority watersheds would consist of a series of classroom seminars and follow-up field sessions. The workshop series format will be like that in the pilot workshop series.

C. Materials

The Water Quality Financial Analysis and Resource Evaluation document, in its comprehensive form, is a two-phase five-step planning guide which includes support material, a completion check-list and planning summary template. It was compiled from the study area analysis, literature review and various other project work products described earlier. It is in the form of a field guide notebook that producers and resource professionals can follow to evaluate the water quality impacts of a grazing management system, develop management strategies to remedy water quality problems, and estimate the economic impact of individual management measures. WQFARE was refined for state-wide use with support of cooperators and participants of 2001 Grazing Management Workshops.

In addition to the WQFARE document, the Extension publications *Managing Kansas Grazinglands for Water Quality* (MF-2086) and Grazing Distribution (MF-515) will be used to illustrate and reinforce concepts developed in the WQFARE materials. Further, other Extension publications of likely interest will be made available to participants.

D. Promotion and Outreach

Without additional funding, the WQFARE process will be promoted as a special function of the Kansas Grazing Land Management Education Program which has been in place for over 15 years. This well established program can integrate the WQFARE concepts and processes into current programing to promote acceptance and utilization.

If additional funding is obtained, a comprehensive promotion program would be developed to recruit cooperators among agricultural support professionals e.g. Extension Agents, the state Watershed Specialists, NRCS personnel, etc. and agricultural producers (for both WQFARE implementation and for additional demonstration development). Agricultural professionals would be among the first to be recruited so that the base of personnel trained in WQFARE protocols can be expanded rapidly to facilitate state-wide experience and adoption. Simultaneously, producer cooperation would be solicited from established contacts of project staff, Extension Agents and their contacts, and through advertising the need for cooperators in appropriate venues.

E. Projected Results

The results of future education efforts will largely depend on how WQFARE is delivered. If outside resources are not available, delivery will be as part of the Kansas Graze land Management Education Program. Limited use of the process will occur as the current specialists have a much broader responsibility than water qaulity programing.

If additional resources are obtained, the delivery rate of project products would be staggered because initial training sessions will be used as a means of training new project staff. A two-person WQFARE team (East Team) would be assembled and trained for working in priority watersheds in and near the Kansas-Lower Republican and Missouri Basins. As they finish training, if resources are available, a second two-person WQFARE team (West Team) would begin training for working in priority watersheds in and near the Arkansas and Cimarron Basins. As each team completes its initial programing in their area, teams will expand their service areas to include the northwest basins (Upper Republican, Solomon and Smokey Hill-Saline) and southeast basins (Marais des Cygnes, Neosho, Verdigris and Walnut).

IV. FUTURE DELIVERY

Future delivery of the WQFARE process will be dependent on the resources available. In addition to funding from Section 319 funds and others, much of the materials used in the delivery of the process will be recovered through fees. Training, workshop, and one-on-one assistance would require the participants to cover the direct and possibly some indirect costs which could include materials, facility rentals, other meeting expenses, and possibly travel for the project staff in some instances.

A. Training Professionals

Training of professional educators and technical assistance personnel would be accomplished through a workshop format. The format would be a 20 hour, multiple-day event utilizing project staff and, eventually, previously trained professional individuals.

The workshop would utilize classroom and field exercises with hands-on training with a detailed manual of the process and suggested related materials. In addition, high quality aerial photos, topography maps, and soils or range site maps would be used. These materials would be generated through the geographic information system (GIS) capabilities of the project.

Representative case study operations would be developed at key locations in the state to include management and economic information. Physical inventories, management data, and economic data would be utilized. The field inventory would be performed by the participants on 1-2 pastures to gain experience and a better understanding of the need for a thorough inventory. When possible, the operator (or a role player) would be available for interview on the management and economic information. Once the benchmark evaluation has been completed and water quality and management concerns identified, development of alternative management strategies would be developed with the operator. The operator then chooses 1-2 alternative strategies (the alternatives may be those proposed or variations developed by the operator) for the participants to evaluate.

After successfully completing the workshop, the participants would be encouraged to work through the process on one or more actual operations with project staff or more experienced participants. The joint work would give the new individuals real-world experience and serve as a review for the previously trained individual.

A registry of trained individuals would be maintained. Updating of the manual and related materials list would be accomplished at least annually. Individuals would be encouraged to repeat the training in 3-4 years for updating and re-qualification.

B. Self-Help Materials

Revision of the publication, *Managing Kansas Grazinglands for Water Quality* (MF-2086) began in 2000 and is nearing completion. The revised publication will serve as a producer self-help guide for improving water quality associated with Kansas grazing land. Completion has been delayed because the original edition is still relevant and useful for describing grazing management principles in a water quality context. Since grazing distribution and seasonal feeding practices were identified as having major influences on water quality, a greater need to develop support material on these topics was identified. Currently a revision of the Extension publication *Grazing Distribution* (MF-515) is in press.

In addition, an Extension publication is currently being developed to help producers qualitatively evaluate seasonal feeding site influences on water quality and select management improvements or new sites if needed. This publication is being adapted from work in Alberta and British Colombia, Canada.

C. Workshop Assistance

Individual landowners and operators would be able to attend a workshop using materials similar to the training materials. The workshop would be 8-10 hours in 4-5 sessions approximately a month apart. Like the training workshop, a representative case study would be used for hands-on experience. Between sessions, the individuals would apply steps of the process to their own land. This would allow project personnel to give limited one-on-one help. For individual participants that enroll by a deadline and supply information on their operation's land resources, the project would provide individual photos and related information to aid in completing the process. This would include, but not be limited to, high quality aerial photos, topography maps, and soils or range site maps. These materials would be generated through the GIS capabilities of the project.

The material used in the workshop would be in a loose-leaf binder with material similar to the training manual. Additional sections would be included for the individual to maintain inventory, management, and economic data, document the alternative strategies and their evaluations, plus a section to document the implementation of the selected plan. When the new management plan is selected, it is proposed that a summary form be completed and filed with the project staff as a "water protection quality plan." The section to document the implementation of their plan will be their "record of accomplishment."

D. One-on-One Assistance

When and if resources allow, direct assistance to individual landowner and operators may be provided. This would include providing materials similar to the workshop plus individualized training and assistance in applying the WQFARE process.

V. MAJOR PRODUCTS AND ACHIEVEMENTS OF PROJECT

The major project products developed are materials that would be used for program delivery as described previously. Materials include the Water Quality Financial Analysis (WQFARE) water quality planning guide (Attachment 1), the associated self-help guide and a revision of *Grazing Distribution* (MF-515). Additional major product include a web site, newsletters and numerous papers, presentations, posters and demonstrations.

A. Web Site

The project has had a dedicated presence on the internet since 1998, started by Ryan Sigg, a student programmer. The project web site URL was registered with major search engines in the first quarter of 1999. The literature database on the project Web site became searchable during the third quarter of 1999. The site has gradually grown and been improved and today contains links to 11 pages directly off the main page (http://www.oznet.ksu.edu/glwq/).

B. Newsletter

___A total of 11 issues of the project newsletter (*The Watershed*) were produced during the life of the project; approximately one every three months (Table 6). Distribution of *The Watershed* was to all project cooperators, interested faculty, County Extension Agents, and other interested individuals. Early issues were comprehensive in nature; later (after August 1999) issues focused on a theme – such as livestock behavior. By project close there were approximately 180 people receiving the project newsletter. Copies of these newsletters are included in Attachment 3.

Table 6. Record of publication of newsletter.

Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1998	Before Newsletter Formulation			X
1999	X	X	X	X
2000	X	X	X	None issued
2001	X	X	X	None issued
2002	None issued			

C. Professional Papers, Presentations, and Posters

As a result of project research and program development, 8 papers have been included in professional publications, 31 presentation have been delivered and 11 posters have been developed and presented at least 45 times. Titles and target audiences are listed in Attachment 4 along with copies of posters if available.

D. Demonstrations and Other Work Products

Establishment of a complete demonstration to illustrate producer water quality planning using WQFARE proved to be premature. Obstacles included needed late-term refinements to educational material and producer time limitations. An enterprise-scale demonstration would have required a long term commitment and extensive record keeping on the part of the cooperating producer. Taking into account landscape characteristics and management ability, several possible long-term demonstration sites were initially identified. Separate demonstrations were established to illustrate various components of the WQFARE pasture evaluation and decision making process.

Riparian Improvement Demonstration

A demonstration (see Attachment 5) showing maintenance and restoration of riparian conditions began in 1999 with treatment of invasive woody species using a combination of basal bark (chemical) and cutting (mechanical) processes. Invading non-riparian species such has hedge and locust were attractive to the livestock for shade and they do not have rooting structures desirable for bank stabilization. Recovery of species adapted to maintaining bank stability was anticipated.

Basal bark control involves applying herbicide directly to the trunk of the tree. Strictly from a management perspective, this treatment method is highly recommended over broadcast spraying except where dense stands of undesirable species exist on prohibitive terrain. However, from a water quality/environmental perspective, basal bark, frill & girdle, and spot treatments are always preferred relative to broadcast (aerial or ground) treatments. This is because broadcast treatments impact non-target species (including animals), rely on one treatment method (chemical) instead of integrating (chemical, biological and/or cultural) controls, fail to account for changes in invasive densities, and usually result in the application of more control (especially chemical) than is necessary. This site was revisited in the Fall of 2001 and the Spring of 2002. Invasive woody species control has allowed rapid recovery of desirable species such as false indigo bush, big bluestem, and Indiangrass.

Gully Erosion Control Demonstration Using Tree Branches

A demonstration was established in the Fall of 2001 to document how appropriate placement of tree branches in a gully can control erosion and promote vegetative bank stabilization. The site was a typical example of gully erosion influenced by livestock behavior (trailing around the pasture perimeter) and the fence placement in the low point of a drainage. Documentation of gully erosion control procedures is found in Attachment 6.

Winter Feeding Practices and Vegetative Cover Demonstration

A variety of feeding practices are applied by grazing land managers. The need to adjust feeding practices to protect water quality is a common need identified. Changes in vegetative cover separating feeding locations from water resources has been monitored at sites controlled by two cooperators. Monitoring consists of repeat photography taken in spring after livestock are removed from the pasture, and in the fall after vegetative regrowth (see Attachment 7).

Runoff Demonstration

A special demonstration using a rainfall simulator was developed to show the effects of stubble height and soil moisture content on water runoff (see Figure 10). Using 4 plots (3 green and one very dry) the simulation dramatically illustrated how infiltration rate and antecedent soil moisture conditions work

Figure 10 Grazing land runoff stop at Agronomy Farm Field Day

in concert to affect runoff. It demonstrated no significant runoff will occur until the precipitation exceeds the infiltration rate and the water holding capacity of the ground cover and soil. The driest plot showed no significant runoff even after the equivalent of 2 3/4 inches of rain (in approximately 30 minutes) had been applied to it. Note: the plots received an additional 2 3/4 inches over the same time period the day prior to the field day. This demonstration was given as part of the annual Agronomy Farm Field Day September 7, 2000.

Improved Fertilization Practices

One cooperator has implemented, for the third consecutive year, improved fertilization practices on brome pastures. Fall rather than winter application is helping to prevent fertilizer loss in runoff from frozen soil, and accurate pasture acreage report from GIS analysis is helping to ensure no more fertilizer is applied than can be assimilated by the grass. Upon the request of the cooperator, project data has been provided to the Nemaha County Coop to help support continued precision application

Pilot Workshop

A pilot workshop format was successfully tested in late 2001 and early 2002. The workshop consisted of four sessions conducted over 5 months using hypothetical data for graze land owned by Dan and Mary Howell (data included in Attachment 1). The first WQFARE pilot workshop was conducted September 24th, 2001 at the Frankfort Regional Education Center, Frankfort, Kansas. Seventeen participants attended this initial workshop. The fourth and final workshop in the pilot series was held in Blue Rapids, Kansas January 24th, 2002 at the Fairgrounds Center. A review of previous sessions was presented and alternative management strategies were discussed. Seven people participated in this workshop and completed a exit survey to provide program feedback. These sessions provided KGLWQP staff with direct interaction with producers, Extension agents, Watershed Specialists, KDHE staff and others. Feedback from these sessions was used to revise and improve WQFARE materials and delivery.

Water Quality Protection Plans

Project data and alternative management strategies for each cooperator have been assembled into water quality planning notebooks similar to those provided to participants at the last WQFARE workshop. The notebooks consists of four major components. First is the 5-step WQFARE process plus a completion check list and five attachments designed to support pasture evaluations, record keeping and the formulation of alternative management strategies. Second is the "Evaluation" section which contains project evaluation data and maps for each pasture and blank maps and record keeping forms for additional evaluation and monitoring by the cooperator. The third section, "Planning", begins with a basin (HUC 8) orientation map showing parcel locations and TMDL fecal coliform priority stream; followed by a parcel location map illustrating roads and parcel locations within sub-basins(HUC 14), a planning summary template and management alternatives. The final section in the notebook is "Support Material" including applicable Extension publications, Watershed Condition Reports and TMDL Plans. Included with the support material is a CD-ROM data disk. This data disk has been prepared so cooperators can print aerial and topographic pasture maps. It also contains *ArcExplorer* software, that, when installed, will allow the visualization and query of project data provided.

E. Support for other Projects

Over the life of the Kansas Grazing Land Water Quality Program we have worked with many individuals, agencies and organizations. Support for other programs/projects began in the second quarter of 1999 when GIS orthophotomaps for 6 locations were prepared for the project *Watershed Dairy Environmental Cooperative.* Numerous orthophotomaps have been prepared for producers, Extension personnel, researchers from KSU Departments of Agronomy, Biological and Agricultural Engineering, and Entomology. In addition, orthophotomaps were produced for FAPRI (Food and Agricultural Policy Institute) University of Missouri - Columbia and for programs such as River Friendly Farms and organizations such as The Nature Conservancy. Support for other projects/programs also included coordinated water sampling for the KSU Research and Extension Fecal Coliform Research Group and providing a 2' x 4' copy of the poster entitled: "*Evaluating Grazing Management Systems: A Process for Improving Water Quality*" to Watershed Specialists for delivery at various producer meetings. These and other project partners with whom we have worked are listed in Attachment 8.

VI. Lessons Learned

Several important insights have emerged from KGLWQP. Lessons learned about water quality program development are derived primarily from field observations, dialogues with grazing resource managers, similar programs in other states and from relevant literature. Lessons learned about using GIS and GPS technologies are based on our experience using these technologies at the parcel scale. These insights can provide useful guidance to future water quality projects addressing graze land concerns or using GIS and GPS technologies.

A. Program Development

Extremes in physiography and grazing management style/preference are common across Kansas. For example, from West to East, annual precipitation varies from 15 to 45 inches, pasture size can vary from several sections to only a few acres, lease periods range from seasonal to multi-year, and the frequency of grain and/or hay feeding ranges from rarely to daily. Variables influencing management and the impact graze land have on water quality are often beyond the control of the manager. Additionally, processes influencing the transport, persistence and assimilation of various pollutants of concern are intricate. These points help reveal the complexity of grazing management systems and the challenge of using generic recommendations to address water quality concerns.

Complex, inter-related factors are best managed as a system. In this case major system variables include hydrology, graze land ecology and economics. Our philosophy for developing and delivering educational material to address graze land water quality in Kansas is to focus on the fundamental concepts of runoff, grazing management, livestock behavior and business management.

The fundamental grazing management principles of stocking rate, uniform utilization, degree of utilization, season of use, kind and class of livestock and systematic rest apply to all grazing types. These principles constitute a decision matrix for any grazing operation and the application of each principles can be adjusted to address multiple variables such as water quality concerns, shifts in climate, markets, and management preferences.

Two basic water quality protection concepts are promoted, reducing runoff and the transport of pollutants to water resources and discouraging direct deposition of livestock waste into water resources. Uniform grazing distribution results in improved waste distribution and vegetative cover conditions needed to reduce runoff. The risk of pollutants being carried by runoff to water resources is characterized by the size of the livestock concentration area, its proximity (distance and slope) to water resource and the abundance of vegetation downslope from the site. The risk of pollutants being deposited directly into water resources is influenced by pasture characteristics such as the presence of streams and crossings, watering facility type and topography and environmental factors impacting livestock behavior such as such as temperature and insect pests (wading is more frequent during warmer weather and some insects encourage wading while other discourage loafing near streams/riparian areas). Attachment 9 discusses water quality protection management measures for graze land. Within this attachment, Table 1 describes Management Measure Components for Improving Grazing Land Water Quality, Table 2 lists examples of Grazing Land Water Quality Concerns and Associated Pollutants, and Table 3 lists USDA-NRCS Conservation Practices Applicable to Kansas Grazing Land and Pollutants Potentially Controlled.

Since problems related to grazing livestock result from their behavioral response to management, weather, landscape, pests etc.; their remedies should be thought of in the same context. Livestock behavior evaluation, therefore, is presented as a tool for both identifying problem sources and for developing management alternatives to correct problems.

Finally, fundamental business management practices such as record keeping and profitability measurement (return on investment and return on equity) are promoted so that the economic implications of management alternatives can be analyzed. Formal water quality planning and the implementation of water quality improvement strategies is currently voluntary in Kansas. Producers decisions about implementing improvements are highly influenced by factors such long-term market cycles, short term cash flows and land tenure arrangements. For these reasons evaluation of the profitability of water quality improvement strategies is essential to program success.

Together, fundamental concepts such as those described above are necessary for developing a reliable and user friendly education program. Materials developed around these concepts should first help the agricultural producer identify the direct and/or indirect source(s) of water quality problems. Then strategies that are reliable and acceptable to the producer can be developed and implemented. Producer monitoring and strategy adaptation (if needed) is also more likely to occur when the logic behind the environmental program is understandable and the product is clearly a benefit to the producer.

B. GIS & GPS

Geographic Information Systems technology has proven to be a valuable tool not only to store cooperator-related information, but also to retrieve, display and analyze that information. Data collected at cooperator sites has occurred in as many as 3 sessions on the same day and there may be as many as 4 different dates on which data has been collected in a particular pasture over as many as 4 years. The project GIS (ArcView v.3.2) allows efficient integration, editing, and updating of all this information. With the GIS, we can ascertain the condition and type (providing this information was collected) of any feature (such as a gate) of any cooperator – in a matter of seconds.

We routinely use GIS to provide cooperators with field data overlayed on digital ortho quarter quadrangle photography (DOQQs)of their pastures. Orthophotmaps (maps made with a DOQQ as background) are also used to orient staff and for noting features and attributes during field data collection. Orthophotomaps have also been used to support WQFARE training and for support of other projects outside KGLWQP. The quality of this aerial photography exceeds by far that which has traditionally been available to agricultural producers and resource management professionals.

<u>Potential Uses of GIS</u>

One potential use of GIS in this project would be for estimating stocking rates based on field evaluation. GIS-derived rates could be compared with the actual stocking rate used by the grazing resource manager. Another type of GIS-related technique that could be incorporated into the project is slope analysis. For example, research suggests cattle prefer grazing slopes less than 5% (said another way, cattle tend to underutilize slopes greater than 5%). Digital Raster Graphics (DRGs) and Digital Elevation Models (DEMs), and/or soil maps could be used to determine areas with greater than 5% slope. This information could then be used as input to determining stocking rate and/or to make expected distribution maps.

Examples of other factors influencing grazing behavior (and thus potentially water quality) that could be incorporated into the GIS include distance from water/shelter, plant species composition (forage availability/quality) possibly incorporating remotely-sensed imagery and weather conditions (temperature, precipitation, etc.)

Livestock spatial and temporal distribution patterns may also be investigated using either radio telemetry or observation. A GIS model with 19 different parameters developed by Brock and Owensby (2000) was able to closely predict ($R = 0.99$) livestock distribution based on utilization data (grazed or ungrazed). Another way to study distribution is through forage removal. These two researchers however, were unable to closely model ($R = 0.28$) in their separate 18-parameter forage-removal model. Without significant model refinement (which the authors suggest might be accomplished with better indicators of forage quality) using remotely-sensed imagery to detect vegetation removal pattern may hold little promise for successfully predicting livestock distribution – at least at a sub-section pasture size scale.

Lastly, GIS could be used to manage graze land water quality data which potentially could be used to develope a predictive model. A quantitative assessment of water quality change within a pasture would ideally involve several water sampling sites – including sampling data from locations where water resources enter and exit the pasture. Such a study would also involve data taken throughout an entire year (for several years) – both with and without cattle present. However, such an effort – even if likely to occur – may reveal little about water quality beyond the confines of the pasture studied. This is because, unlike crops, livestock move and can react to environmental conditions, features, and management (all 3 of which may vary by pasture) in dynamic ways.

GPS

Global Position Systems (GPS) technology allows the precise position of a feature to be determined. The project field computer (Fujitsu Model 1200) allows synchronization with the GPS unit (Trimble AgGPS 132) so that attributes of features in the field can be entered as their positions are collected. GPS-collected points are used as raw positional input into the GIS.

The project GPS is also used to locate digital photographs taken to depict pasture features and/or conditions. GPS referenced photographs have allowed staff members to re-visit a unique location in a pasture to document changes over time – without the need for a permanent marker.

Accuracy of the GPS has been shown in the field to be affected by: 1) radio signal strength [i.e. how far signal is away from base station] 2) number of satellites captured by GPS to determine position [i.e. more satellites usually indicates a more precise position] 3) proximity of relief [trees, valleys, buildings, powerlines, etc.] can alter positioning 4) cloud cover [cloudy days usually have poorer satellite signals than sunny days] 5) atmospheric factors [rain, lightning, dust, haze, smoke, temperature, humidity, etc.] can also affect positions derived from the GPS signal.

Despite the many influences that might degrade positional accuracy, the locations gathered by the AgGPS 132 receiver are usually accurate to under 2 meters. In terms of area, two meter accuracy (in any direction) represents an accurate location somewhere within a 16 square meter area. Divide 16(square meters) by the total number of square meters in an acre (4046.8725) and it is just under four tenths of one percent of the total area. Thus per acre accuracy of the AgGPS

132 experienced in the field is about 99.6% – which seems sufficient to investigate pasture-level phenomena.

VII. CONCLUSION

This project developed an understandable management resource that is not available elsewhere. It walks cooperators through a process aimed at improving grazing management and water quality and is capable of incorporating other management goals simultaneously. This resource contains step-by-step instructions for completing the process as well as the technical resources to aid producer understanding and implementation. Completing the process will result in a comprehensive grazing management improvement plan that can also serve as a water quality protection plan.

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VIII. FINAL BUDGETS

Kansas State University
Department of Agronomy
Grazing Land Water Qaulity Education Program
Part 1 - 1997

Description	State Water Plan Amount
Salaries and Wages	$20,212.10
Contractual Services	2,245.39
Travel	1,907.47
Supplies	2.486.18
Capital Outlay	19,806.86
Total Budget	46,658.00

Kansas State University
Department of Agronomy
Grazing Land Water Qaulity Education Program
Part 2 - 1998

Description	Section 319 Amount	KSU Amount
Salaries and Wages	$51,667.21	$40,269.00
Contractual Services	20,615.81	0.00
Travel	6,995.48	0.00
Supplies	6,562.10	0.00
Capital Outlay	0.00	0.00
Total Direct Costs	85,840.60	40,269.00
Indirect Costs	8,600.00	29,309.00
Total Budget	$94,600.00	$69,578.00

Kansas State University
Department of Agronomy
Grazing Land Water Qaulity Education Program
Part 3 - 1999

Description	Section 319 Amount	KSU Amount
Salaries and Wages	$97,371.75	$41,683.00
Contractual Services	7,053.37	0.00
Travel	2,604.47	0.00
Other Contractual Services	313.50	0.00
Supplies	3,764.17	0.00
Capital Outlay	0.00	0.00
Total Direct Costs	111,107.26	41,683.00
Indirect Costs	11,110.74	40.991.00
Total Budget	$122,218.00	$82,674

Kansas State University
Department of Agronomy
Grazing Land Water Qaulity Education Program
Part 4 - 2000

Description	Amount	Amount
Salaries and Wages	95,232.00	46,674.00
Contractual Services	5,200.00	
Travel	9,400.00	
Supplies	1,275.00	
Capital Outlay	0.00	0.00
Total Direct Costs	111,107.00	46,674.00
Indirect Costs	11,111.00	39,281.00
Total Budget	122,218.00	85,955.00

Kansas State University
Department of Agronomy
Grazing Land Water Qaulity Education Program
Part 5 - July 1, 2001 to December 31, 2002

Description	Amount	Amount[1]
Salaries and Wages	$104,355.34	$50,217.69
Contractual Services	2,559.74	0.00
Travel	1,472.09	0.00
Other Contractual Services	820.55	0.00
Supplies	1,864.49	0.00
Capital Outlay	0.00	0.00
Total Direct Costs	111,107.21	50,217.69
Indirect Costs	11,110.72	43,739.69
Total Budget	$122,217.93	$93,957.38

[1] As of August 3, 2002

Total Contributions:

State Water Plan	$46,658.00
Section 319	461,253.00
KSU	332,164.00
Total	$840,075.00